

## Structure and Properties of Atoms

**PS-2 The student will demonstrate an understanding of the structure and properties of atoms.**

**PS-2.3 Explain the trends of the periodic table based on the elements' valence electrons and atomic numbers.**

**Taxonomy Level:** 2.7-B Understand Conceptual Knowledge

### Key Concepts:

Periodic table organization: period, group or family

metal, nonmetal, metalloid

atomic number, atomic mass

valence electron

As periodic tables vary greatly both in format and in the information which they provide, it is very important that students are comfortable using the periodic table that will be available on the End-of-Course Test. Each student should receive a copy of this periodic table (revised August 2007) at the beginning of the physical science course and be encouraged to use it for **all** homework, class-work, and assessments. The periodic table can be downloaded from the following website:

[http://ed.sc.gov/agency/offices/assessment/programs/endofcourse/documents/periodtablerevised08\\_14\\_07.pdf](http://ed.sc.gov/agency/offices/assessment/programs/endofcourse/documents/periodtablerevised08_14_07.pdf)

**Previous/Future knowledge:** Students were introduced to the basic organization of elements on the periodic table in the 7<sup>th</sup> grade (7-5.4). The concepts addressed in this Physical Science indicator will develop an understanding of how the periodic table can be used to discern an element's atomic structure as well as an understanding of how an element's position on the periodic table can be used to predict how it will bond, its chemical reactivity, and its chemical properties (PS-2.5 and PS-4.1 through PS4.10). Students should understand the reasons for the trends and therefore use logic to describe them. The periodic table is a valuable tool used by chemistry students from high school through college and in the workplace. With each subsequent chemistry course, students will learn more information that can be determined by the element's position on the periodic table.

### It is essential for student to

- Understand the parts of the periodic table in order to understand trends
- Know that *period* is the term used to describe a horizontal row on the periodic table.
- Know that *Group* and *Family* are terms used to describe a vertical column on the periodic table.
- Locate major categories of elements such as the *metals*, *metalloids*, and *nonmetals* (metals and nonmetals were introduced in 7<sup>th</sup> grade).
  - o *Metalloids* should be identified as elements that have some characteristics of metals and some of nonmetals; they border the line between metals and nonmetals on the periodic table.
- Locate referenced elements when prompted with a period number or group number.
- Determine a given element's *atomic number* (number of protons).
- Determine the number of electrons that an atom of a given element contains (the same as the number of protons, i.e., its atomic number).
- Determine how many energy levels are occupied in a given element by recognizing that the period in which an element appears on the periodic table indicates the number of occupied energy levels.
  - o For example, all elements in period 4 have four occupied energy levels.
  - o This is an introduction to quantum theory that will be studied in chemistry.
- Recognize a given element's *atomic mass* (the weighted average of the masses of the naturally occurring isotopes of the element), by recognizing that the atomic mass of an element is a decimal

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number. It is always larger than the atomic number and generally increases for each successive element

- Determine the number of *valence electrons* (electrons in the outer-most energy level) for selected groups of elements when given the element's group number or name.
  - o Elements in groups 1-2, 13-18

Group or Family	Name	# valence electrons
1	Alkali metals	1
2	Alkaline Earth Metals	2
13		3
14		4
15		5
16	Oxygen group	6
17	Halogens	7
18	Noble Gases	8 (except He)

### It is essential that students

- Understand some of the trends in the properties of the elements that the periodic table displays.
  - o Periodic trends in the number of valence electrons:
    - From left to right ***across periods 1-3:*** (Not from left to right across periods 4-7 as a deeper understanding of quantum theory is prerequisite for understanding these trends.
      - \* Atoms of all these elements contain one more valence electron than the atoms of the previous element.
    - From top to bottom within any group:
      - \* Atoms of all of the elements in a given group contain the same number of valence electrons.
  - o Periodic trends in the number of energy levels:
    - From left to right across any period:
      - \* Atoms of all elements in a given period have the same number of energy levels.
    - From top to bottom within any group
      - \* Atoms of each subsequent element (from top to bottom) in any given group contain one more energy level than the atoms of the element above.
- Use knowledge of those trends to predict properties of elements relative to each other (not specific values, but given two elements, determine which element will have the higher value for each of the trends listed above).

### It is not essential for students to

- Recall the history of the periodic table although the history of the periodic table highlights its purpose and, therefore, would serve as a definite aide in helping students comprehend the value and relevance of this concept;
- Understand the carbon-12 standard for atomic mass;
- Calculate a weighted average;

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- Determine the number of valence electrons for the Transition Elements, elements in groups 3-12 (including the Lanthanide Series and the Actinide Series) as the transition elements have various numbers of valence electrons depending upon the stability of their “d” and “f” orbitals;
- Understand reasons that there are exceptions to trends or be able to cite exceptions to trends (Students should realize, however, that there are exceptions to some of the trends);
- Understand periodic trends for atomic radius within a period, or other trends such as electronegativity, electron affinity, ionization energy, ionic radius or shielding effect.

### Assessment Guidelines:

The objective of this indicator is to *explain* trends in atomic structure that are revealed by the periodic table, therefore, the primary focus of assessment should be to construct cause and effect models that show that if an element is found at a particular location on the periodic table, then certain characteristics of that element’s atomic structure can be described relative to the other elements on the table. The cause-and-effect for this indicator only refers to knowing that an element has a certain position on the table because of its atomic structure. The reasons for the trends are beyond the scope of this course. Assessments should test the students’ ability to apply this concept to any element or set of elements (other than those noted in the instructional guidelines as not essential). Assessment should not be restricted to memorized examples.

In addition to *explain*, assessments may require students to

- Exemplify trends on the periodic table;
- Infer some aspects of atomic structure of an element based on its position on the periodic table;
- Compare some aspects of atomic structure of two or more elements based on their relative positions on the periodic table.